# The Difficulties of Implementation of BIPV in Portugal, rejection or abstention?

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**Abstract:** The position of Portugal in the context BIPV is negative and controversial. While some countries identified with odd or difficult conditions for the spread of these systems, succeeded in overcoming the constraints and are increasingly using them, Portugal, with one of the highest solar radiation levels within Europe, is not seriously considering their use. One must ask, "What hinders the penetration of the BIPV system into the Portuguese market?" The purpose of this work is to try to get an answer to this question. First, it will define the concept; the characteristics and the advantages of BIPV applications in Mediterranean countries. After, it will define the reasons that justify the difficulty of the BIPV development into the Portuguese market. Then it will discuss the most recent measures that are being consolidated in Portugal in order to invert the actual situation. This includes ongoing private projects and public investigation developed in Universities. In the end, it will be presented a case study of a BIPV application to a Portuguese Hotel, focusing on which allows the viability of these applications.

## 1 INTRODUCTION

The Building Integrated Photovoltaic system (BIPV) is quite used and well-known in some countries while in others it has smaller relevance mainly due to the scarce information available at the market and to the high short term costs. BIPV concentrates several advantages starting from its capacity of not only producing energy but also by its ability of becoming a component of the building, replacing other construction materials and therefore reducing significantly the overall cost.

This system can be considered as one of the format investments in renewable energies that better fits the actual urban reality, where space is more and more scarce and valued. Besides other particular advantages, it is a clean and silent energy, and it does not produce noxious gases, including $CO_2$. In other words, when installed, BIPV does not produce any form of negative environmental impact.

Sustainability is changing the way of engineering new buildings. The concept of the sustainability and of the integration of renewable energies has affected all the aspects of the design, engineering and construction. Today the design has to

integrate not only the form, the function, the aesthetics, but also the energy efficiency and the ecology. The photovoltaic modules, when well executed and integrated, are easily framed to the construction concepts.

In order that a BIPV design become successful, it is important that all the professionals involved in the process, know its characteristics, composition and type of solar cells used, different sizes available and the possible locations for the installation.

This is how this paper begins, approaching concepts and characteristics in order to focus afterwards on the Portuguese reality as well as on the difficulties of introducing a BIPV system in Portugal and on the change of attitudes needed in order to invert the actual reality.

## 2 THE BIPV CONCEPT

Photovoltaic are strongly represented in the market through different technologies such as Monocrystalline, Polycrystalline or Thin-film (figure1). All these technologies use semi-conductor materials that, in ninety percent of the cases, are composed by silicon. What marks the difference between these three types of solar cells is not only its visual feature but mainly the efficiency rate and the costs associated to different manufactures. For instance, Panel Amorphous Silicon cells (thin-film) require less semi-conductor materials than the polycrystalline ones, having consequently an inferior cost, but at the same time they are less efficient in terms of energy production (table 1).

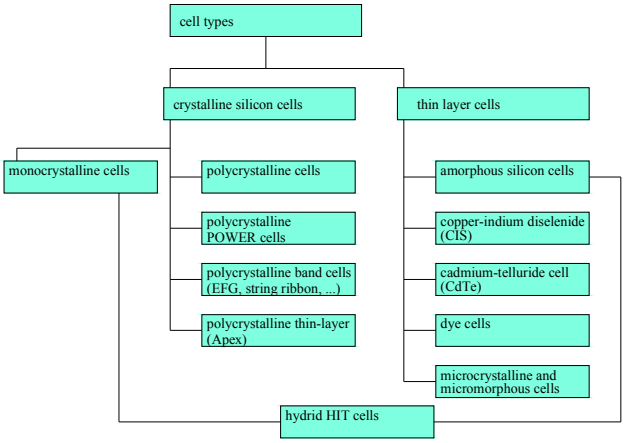


**Figure1: Types of solar cells (The German Solar Energy Society, 2005)**

**Table 1 Maximum efficiencies in photovoltaic (The German Solar Energy Society, 2005)**

| Solar Cells Material | Cell efficiency (Laboratory) | Cell efficiency (Production) | Module efficiency (Series production) |
|---|---|---|---|
| Monocrystalline silicon | 24.7% | 18% | 14% |
| Polycrystalline silicon | 19.8% | 16% | 13% |
| Ribbon silicon | 19.7% | 14% | 13% |
| Crystalline thin-film silicon | 19.2% | 9.5% | 7.9% |
| Amorphous silicon* | 13.0% | 10.5% | 7.5% |
| Micromorphous silicon* | 12.0% | 10.7% | 9.1% |
| Hybrid HIT solar cell | 20.1% | 17.3% | 15.2% |
| CIS, CIGS | 18.8% | 14% | 10% |
| Cadmium telluride | 16.4% | 10% | 9% |
| III-V semiconductor | 35.8%** | 27.4% | 27% |
| Dye-sensitized cell | 12.0% | 7% | 5%*** |

* *in stabilized state*

** *measured with concentrated irradiance*

****small production runs*

In any case, the way how the photovoltaic modules operate is always the same. That is, the cells capture the solar energy (photons) carried by the solar light and convert it into electrical energy. Solar energy generates a DC electrical energy that can be stored in batteries or passed through invertors becoming AC energy. This energy can then be used directly in house appliances or be delivered into the electrical network. Besides the modules and the construction materials used in its integration into the building, BIPV system is also composed by structural elements that assure its local fixing, beyond electrical cables, battery system and the essential invertors.

## 2.1 Integration of the System

The main applications of the photovoltaic in buildings can be undertaken in facades, roofing and atriums. This paper won't detail the functional aspects of these systems, nor the factors that can reduce their efficiency, but, in a brief way, it will describe their advantages and functioning in each integration system:

- Facade System - This system can be found in the form of curtain walls, opaque facades, as well as in the form of shading elements, as awnings and canopies.

The photovoltaic represented as curtain walls can bring high contributions to the building, such as natural light or visual contact with the exterior. The facades

(composed by PV, air layer and masonry) can contribute as an interesting element of passive solar energy. This is due to its high thermal inertia, as well as, through the transfer of heat generated in the interior air layer between photovoltaic and masonry (or glass). In a process of heat transfer through natural convection, the final benefit is mutual, so much for the thermal comfort of the interior atmosphere, as for a better efficiency of the modules (Kiss and Kinkead 1995)

In this solution, the architects can choose among different spacing between cells, colours and sizes. This way it's possible to conjugate production of energy, aesthetics and thermal comfort. In addition, PV cells can also show some advantages in terms of costs when compared with some other construction materials used in facades, like, polished stone, commonly used in Portugal (table 2).

**Table 2 Cost for different types of facades (Scheuten Solar, 2005)**

| Materials for facades | Cost/$m^2$ (euros) (approximate value) |
|---|---|
| Polished stone | • 1200 |
| Photovoltaic | • 800 |
| Stone | • 700 |
| Glass façade | • 600 |
| Metallic Foils | • 250 |

- Roofing Systems - This system can be applied in tilted roofs as well as in plane coverings. There are several advantages in its use besides production of energy since it also reduces maintenance needs. In addition, it pays back the installation costs in a shorter period, due to its privileged positioning for solar reception. BIPV application in plane coverings has others advantages like its capacity to extend the roof life through its property of protecting the insulation and membranes from ultraviolet rays and from the degradation caused by rain (Eiffert and Kiss 2000).

- Atrium Systems – This System join glass and PV modules providing different shading levels that can affect thermal comfort as well as the use of natural light.

In any of the identified situations of BIPV integration, the following factors should always be taken in consideration in all of the design and execution phases:

- Environmental Factors – Climatic data (temperature, solar radiation) must be known as well as the latitude of the place and the solar orientation and inclination angle of the modules. Also care must be taken in order to avoid shading from the surroundings (trees and neighbouring buildings).
- Structural Factors – This includes requested energy, weight and size of the chosen modules, ways of fixation and operating and maintenance strategies of the BIPV system.

- Aesthetic and Economical Factors – The module should fit in the surroundings and must seek harmony with other construction materials integrated into the same building, for instance photovoltaic and wood or photovoltaic and glass. It should be multifunctional and replace, whenever possible, other construction materials.

# 3 THE EUROPEAN STATE-OF-ART

For the success of the BIPV system, the knowledge and the active involvement of construction professionals is essential. The relevant identification of the technological factors, architecture and technical barriers need to be diagnosed and solved. The main goal will consist on the constant evolution and development of the system and on finding economical alternatives and solutions for the market that can promote the diffusion of BIPV.

## 3.1 The Barriers and Solutions in the European Market

### 3.1.1 High costs of production and installation.

The high costs of the BIPV systems can be undertaken in several ways:

- Through the prefabrication of different materials: roofs, glass structures for windows/walls or skylights, substructures and even their integration in the own construction material (like, for example, tiles).

A cost reduction of 50% can be achieved for substructures and assembly costs. A similar strategy can be applied in the development of assembly of structures for tilted roofs and elevations (Eiffert and Kiss 2000).

- Through home financings, many owners are choosing to use BIPV. This system, besides replacing other construction materials (cost reduction that can reach 30% to 50%, in some cases), has cost benefits that are justifiable. While paying the bank loan, it is possible to take advantage from the benefits of the use of the photovoltaic system through the direct use of the energy produced and also from its sale to the National Electrical Company.

### 3.1.2 Flexibility versus Budget.

Some projects that use BIPV request variable forms and sizes. It becomes quite common and, at the same time, necessary because flexibility should always be present as one of the main characteristics of BIPV. Those variations can be observed from the solar cells and spacing among these, as well as in the modules themselves. However, the larger difference between diversified modules and standard modules, the greater the cost is of the system in the market.

The above mentioned economic factors, as well as, aesthetic factors, can be optimized throughout the planning during the preliminary project phases. Another

factor can be to give larger attention to the construction materials that take part in the building along with the photovoltaic. These should be equalled in dimension, structural properties, quality and mainly in their life period.

As the cost of photovoltaic tends to become high when its production is limited to reduced quantities, it would be important that professionals of the branch, architects and construction builders got together and approve the use of the system at a larger scale and, in this way, they could join purchases, reduce costs, enlarge the market and finally, make the production possible.

### 3.1.3 Non-technical barriers (lack of information)

Another problematic factor is the lack of knowledge not only demonstrated by the architects, but also by the construction demanders and public in general.

Resolution has been undertaken in several countries through the creation of manuals made accessible to the public and public training. Moreover, appropriate drawing tools and analysis of the efficiency of the system have, as well, been implemented.

Regarding education and public knowledge, some European countries are including in their education program information on how to work with photovoltaic systems, their importance and integration forms (Nordmann 1995). Another factor of likewise high importance is the role of public institutions, which play a key role in their introduction and have a great power of rendering this technology and made it available for the general public.

## 4 THE PORTUGUESE STATE-OF-ART

Portugal is a country that has special conditions (along with Greece) in terms of solar exposure for the production of electrical solar energy. However, the levels of investment on these systems are quite insignificant and primarily of the following type:

- Houses (Stand Alone Systems) - Installed in the southern part of the country (Alentejo and Algarve) without any architectural integration;

- Some applications like “urban furniture”, highway signalling and very limited cases of public photovoltaic lighting;

- Small installations connected to public net (up to 5 Kw systems);

- Finally, the mega investment planned to be the biggest solar photovoltaic plant of the world (with a foreseen production of 64 Mwp), to be built in Moura (Alentejo) during the next few years.

The examples here referred do not reflect any cases of Building Integration photovoltaic system (BIPV), with the exception of some isolated cases, like the one of the German School in Lisbon that is an example of BIPV (roofed photovoltaic) applied in Portugal.

It is public knowledge that some market promoters had been trying to find several

solutions for some new investments and opportunities for the introduction of the BIPV systems. However, there are many factors that lead to entropy and disinterest to the final application of BIPV in Portuguese construction.

## 4.1 The Portuguese Barriers

One of the major problems of the BIPV systems, as already mentioned, is their high costs. However, no direct references to the price of the photovoltaic modules will be pointed out here because this problem is identical to what happens in any other country. It only differs on the potential installation costs. Therefore, in Portugal, it is possible to identify several types of difficulties as it will be shown forward.

### 4.1.1 Political aspects and legislation

Regarding political aspects and legislation it is possible to point out the following:

- Lack of a real political involvement in getting 39% of the total energy consumed from renewable energy sources until the year of 2010, as assumed two years ago by the Portuguese authorities, as well as, the lack of an effective political strategy for "Sustainable Development."

- Recently, Portuguese authorities established the goal of producing 150 Mw of photovoltaic energy. However, there has not been the concern of defining quotas of production for the several types of markets of solar energy. This would have been a desirable protection measure for the BIPV installed in small facilities protecting this share of the market from the competition of the big plants, which benefit from several market advantages.

- The price of the electrical energy has a much reduced tax burden in Portugal (5% in all of the segments) when compared with other European countries in which the applied taxes vary between 45% and 60%. In this way, there is little incentive to invest in solar energy systems, unlike other countries.

- Green prices, or in other words, the sale of energy to the net through photovoltaic systems, are divided between systems installed up to 5 kW or above 5 kW. The standard prices are considered reasonable, even somewhat interesting, but, in this matter, the problems result in the application of legislation associated to this market; these being:

a) The maximum period of supply to the net cannot exceed 15 years;

b) At least 51% of the production must be for self-consumption, limiting, this way, the expected profits of the investors;

c) Regarding the technology prices, the support given to direct investment is inadequate.

### 4.1.2 Technical Services

In what concerns technical services, usually, the representatives in Portugal of this

type of offer are small companies that have standard technical problems (fail to satisfactorily dominate the technology). Usually, mistakes like design mistakes and lack of technical information, are very common. In addition, the public investment in Technical Training for solar photovoltaic installers is scarce.

### 4.1.3 Technical Information and training

Regarding the technical information and training made available in Portugal, it is observed that:

- Most of the projects depend on technical information that comes from abroad, usually from the technical cabinets of the suppliers (headquarters). Because the Portuguese market is a marginal market, the information delays in arriving.

- Lack of academic updated curriculum associated to renewable energies (studied in the most simplistic form, BIPV is not focused) in the engineering and architectural courses. Sustainable Construction / Architecture issues are only now beginning to be part of some academic curricula.

### 4.1.4 Market Aspects

The difficulties of implementation of BIPV into the market can, in part, be justified by the economical model followed by Portugal in the last 17 years that has been strongly focused on the Construction Sector. In these years, the Construction Sector was mainly centred in the amount and less in the quality, as well as, limiting the application of new concepts like Bioclimatic buildings, Sustainable Construction, new construction materials (like BIPV) and different options for energy efficiency or energy sources in buildings. Tourism, one of the most important sectors of the Portuguese economy, also registered the same dynamics, based on mass tourism segments, characterized by tourism buildings (hotels and accommodation) which offer no added value in this matter (Pereira, 2005).

### 4.1.5 Structural and Organization

Some structural and organization barriers can also be pointed out:

- The public network for receiving the energy produced by renewable sources is still far from the market expectations. In other words, the public administrative organizations (that are responsible for these administrative mechanisms) are still an obstacle because of all the bureaucracy involved in these processes.

- Electric codes and construction regulations are unclear regarding these new applications.

### 4.1.6 Cultural Aspects

The Cultural barriers are easily identified. Portuguese cities do not easily accept the integration of buildings with differentiated and more daring architectural components, mainly in the inner cities of the country, connected with very rigorous urban concepts.

### 4.1.7 Negative experiences

Finally, other aspect that must be mentioned is that there were, in the past, some negative experiences in this field. In the 80's, thermal solar energy in Portugal achieved a negative image due to some technical problems occurred. For a long period, solar energy in general has been disseminated as a bad idea. The association of that last experience with the high investment risks in the solar energy in general (where the solar photovoltaic is still being punished in regards to its price), generates a pre-conceived negative idea that is still very present in the market today (Collares-Pereira, 2004).

## 4.2 The Portuguese Initiative

After numbering all these facts that hinder the penetration of new concepts and diminish the demand for the differentiation market, it is possible to register that some changes are already happening in the market what foresees the opening of new opportunities for BIPV. Those changes can be identified as follows:

### 4.2.1 Opportunity for the differentiation and increased value in construction

With the exhaustion of the mentioned economic model, mainly focused on the amount and less on the quality and efficiency, companies, real estate promoters and market leaders, are now beginning to identify the added value for the market of new solutions. It is possible to verify that the construction sector is now much more concerned with quality (evidenced in the use of new materials and concepts) and trying to develop an offer for more demanding customers with economic patterns above the average.

### 4.2.2 Implementation of the Directive for the Energy Efficiency in Buildings

The implementation of the Directive for the energy efficiency in buildings is definitively the largest springboard of structural changes in the construction sector. Being January 2006 the deadline for the application of the Directive 2002/91/CE to the Construction market, a strong change is expected in the regulations of the construction business in Portugal. This new Directive will also force a change in the level of preparation of architects and project managers and in the enforcement of new requirements and definition of new goals, allowing foreseeing a clear change in the general atmosphere of the whole sector.

- Two factors that should enhance this new legislative framework are the following:

a) The new legislation will force feasibility studies for the implementation of renewable energies in buildings which will be an important opportunity for BIPV;

b) This new legislation will also encourage the control of natural lighting where semi-transparent facades will play an important role. This will spark the search for double and triple glass facades, however characterized by other types of glass with

particular demands in control of natural light and shading purposes. Such aspects will allow an opportunity for the new generation of semi-transparent and opaque Thin Film modules that assumes today an interesting efficiency level in energy production.

### 4.2.3 Open of new preference markets. The complementary offer to tourism and real estate

With basic strategic developments for the competitiveness of the country, the Tourism sector must contradict the tendencies of the last years and bet strongly in chains linked to the concepts of Eco-Tourism, Environmental Tourism and Sustainable Tourism for high and medium quality markets. This focus will allow BIPV to be a strong tool for an environmental marketing for the tourism component (Pereira, 2005).

### 4.2.4 Tendency for a larger political discussion regarding sustainability

Today there is a tendency for a larger political discussion regarding sustainability, specifically regarding local and regional matters (Local Agenda 21 and Agenda 21 for Tourism). There is a critical discussion of this important development in the cities. This intensification will promote the need of local investments in renewable components in buildings and will create the necessary atmosphere for the implementation of BIPV in relationship with Sustainable Cities.

### 4.2.5 Closer proximity to knowledge centres for Renewable Energies

The strong growth of the Renewable Energy market observed in Spain will allow a larger growth of the Portuguese BIPV market. Till now, BIPV technology was basically developed in Northern Europe, rendering difficult, in this way, its promotion and study in an outlying country such as Portugal.

## 4.3 The Portuguese Case Study

The Hotel Silvares, real estate enterprise promoted for C&A Novais, is located in Guimarães, Northern Portugal and it still is in a design phase. It is an enterprise that will be developed based on Sustainability concepts in the tourism business. Its goal is to promote the integration of quality, environment, energy and economic factors in the whole project. This case study, developed by the Portuguese architect José Ribeiro, will present the BIPV perspective, with regards to renewable energies, as one of the most important factors.

The project's development was initiated with some basic limitations regarding the location and available space, not allowing the appropriate design for the best use of solar radiation.

The Building was planned in order to incorporate monocrystalline photovoltaic systems (AET Albasolar, 2005) in facades and roof, and also to incorporate the necessary shading systems (Figure2).

In facades facing Southwest and southeast, the integration of the module will be proposed along the rows of windows, as shading systems. In the happenstance of smaller solar incidence and smaller rate efficiencies, a similar material will be used in the building construction but not with photovoltaic characteristics. In this application, the building will benefit in three ways: the production of energy, solar protection and replacement of materials.

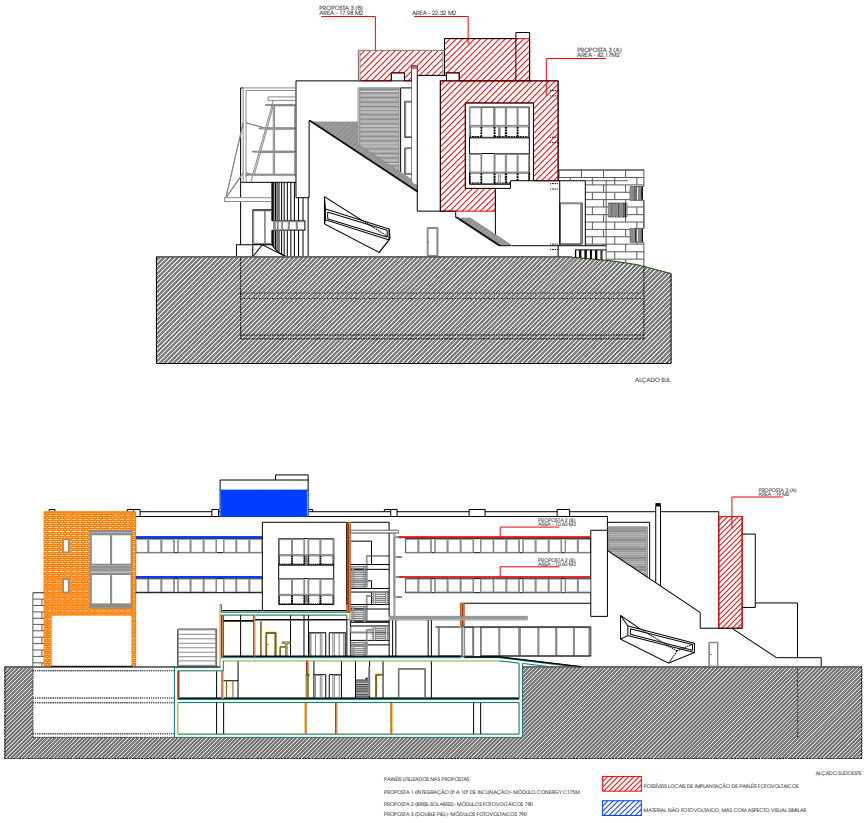


**Figure2: South Façade and East/West cross section showing where BIPV will be integrated in the building.**

The Southern façade will contain the same module and will be integrated as a curtain wall. There is a concern in defining the spacing among modules and masonry, expansion joint, the structure's weight and insulation. Besides the energy production, thermal comfort, and reduction of construction costs, this application guarantees an important marketing effect on the Tourism market.

The roofing will be incorporated with two types of systems: the photovoltaic and the solar thermal. In this project, a larger concentration of photovoltaic panels in the covering is observed, mainly due to its high production capacity, increased available

area and more economical integration. During the definition of the area for the modules, it was considered the access between modules, shadowing of the terrace and finally the insulation and infiltration in the covering.

# 5 CONCLUSION

This work describes the photovoltaic concepts, characteristics and used forms, rendering evident its high technology and multipurpose. Advantages and disadvantages have been identified. Different causes that hinder the penetration of BIPV systems have been pointed out. However, Europe and other continents are trying to solve and eliminate economical and technical barriers for BIPV. The difficulties have been overcome through different solutions such as prefabrication, replacement of materials, funding and other incentive means.

Due to several related factors, in Portugal the situation is processed in dawdling way, however, not static. On the contrary, more and more forces have been united. They have witnessed BIPV in the education system, as well as, in the mentality and in the Portuguese construction sector.

# 6 ACKNOWLEDGEMENT

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